

REMARKS

Reconsideration of this application and entry of this Amendment are requested. Claims 1-11 remain active in the application subsequent to entry of this Amendment.

Attached is an evidentiary declaration of the senior inventor made May 2, 2003. This evidence is discussed in the remarks that follow.

It is proposed to amend the claims in order to more particularly point out and distinctly claim that which applicants regard as their invention and to address the issues raised in items 2 and 10 of the Official Action. Specifically, it is proposed to insert an inadvertently deleted arch to lines from the text of amended claim 1 and to revise claims 10 and 11 responsive to the examiner's comments. The examiner has objected to claims 10 and 11 on the basis that the subject matter 'charge transporting compounds' is not clear or is inconsistent. From the context of the description the expression 'charge transporting compounds' refers to any of the electron transporters, hole transporters or light emitters; the use of additional electron/hole transporters and/or light emitters is supported by page 13, lines 16-21. To avoid confusion the words '... charge transporting compounds' are replaced with the expression '... a hole transporter, an electron transporter or a light emitter', without broadening the scope of the claims.

The balance of the Official Action relates to three separate prior art-based rejections of various groups of claims based upon combinations of from three to five references. Applicants disagree with the manner in which the references are applied and the examiner's interpretation of them and provide now a more detailed explanation of the information actually provided in the documents cited and relied upon.

The basis of the examiner's concern appears to be that it would be "obvious" for the skilled person to make the combination of Mori et al U.S. 5,281,489, which describes a single layer device with different materials, and the JP patent 9-289081, which describes a two layer device with similar materials in order to arrive at the

claimed invention. In fact, the examiner goes further than this and in the argument set out on page 4, lines 7-18, of the Official Action, relating to JP '081 the examiner suggests that this patent also shows a one layer structure. Applicants cannot agree with this conclusion and suggest instead that JP '081 clearly only details the use of two discrete layers – the three functions mentioned by the examiner do not appear together in any one of the JP '081 layers. Applicants explain this.

Thus, page 8 of JP '081, third paragraph, clearly details the deposition of the hole transporting layer (3), and page 10, third paragraph, clearly details the deposition of the electron transporting layer (4). The patent clearly describes two discrete layers one for the electron and one for the hole transporting compounds. Further evidence of the existence of two layers is suggested by the comments on page 8, final paragraph, where it refers to the use of leveling agents and coating improvers, which are to be used before the application of the organic electron transporting layer.

The examiner's argument on page 4, line 13 of the Official Action, that in JP '081, '... the layer provides the three functions of hole transportation, electron transportation and light emission ...', is inconsistent with the reference itself which states in the paragraph bridging page 10 and 11, that '... In the organic electroluminescent element of the present invention, at least one among the hole transporting layer 3 and organic electron transporting layer 4 must also function as the light emitting layer ...' It does not anywhere suggest that the BF₂ complex will behave as both an emitter and electron transporter. Indeed, had they come to this conclusion, they would surely not have needed to lay down the second electron transporting layer (4). It is apparent therefore that the teachings in JP '081 do not clearly point the reader towards a one layer system – in fact quite the opposite.

In summary, JP '081 uses a hole transporter and an electron transporter in two physically separate layers and in either one or both layers they can add the dopant BF₂ complex, whereas in the present invention there is a hole transporter, electron transporter and light emitter in one physical layer, wherein the light emitter and electron transporter can be the same compound, i.e. the BF₂ complex. Additionally on

page 11, second paragraph, of JP '081 it clearly details that the BF2 complex is a dopant material, and there is no mention that the BF2 complex is being used as an electron transporter. In distinct contrast, applicants' claim 1 clearly identifies this as a key feature of their invention, albeit that applicants do describe in their application on page 13, lines 22-23 that the BF2 complex can be optionally used as a dopant. Consequently the reader of the JP '081 patent would conclude that there was no reason to try combining these functions into a single layer because this reference has clearly demonstrated the successful use of a two layer arrangement involving the BF2 complex.

While the Mori et al U.S. '489 patent does describe a single layer comprising the three functions of hole/electron transporting and light emitting, Mori does not incorporate the compounds of the present invention, and as such does not provide persuasive evidence to the skilled person to adapt the JP '081 components to provide a single layer. There is a trade-off between single and multiple layered devices; while the deposition of separate layers is costly, time consuming and difficult to control, two layer devices are known to be efficient in both energy and light output, which makes them a desirable product. Indeed, devices using a double layer structure were introduced to the art by Tang and VanSlyke (Applied Physics Letters 51(12), 913 (1987)) specifically because this structure promoted high efficiency. To quote from their abstract, "emission ... confined near the organic interface region. High external efficiency ... and brightness are achievable" The organic interface region is essential to the improvements in Tang and Van Slyke's device, and for this interface to exist, a double (or multiple) layer structure is essential.

The production of single layer devices, which are cheaper to produce but in general have lower efficiencies, has been disclosed in many applications. Achieving efficient devices from a single layer structure which is convenient and inexpensive to fabricate has been an outstanding problem, which the present invention has overcome. There is no indication in the prior art to suggest that use of applicants' specific boron compounds will lead to an increase in efficiency of a single layer device. By way of example, the Daub et al article (of record as cited in the International Search Report) in

the IPER attempted to produce an organic LED using a single layer with a BF₂ complex but failed to do so, thus demonstrating that the selection of the correct electron/hole transporter and light emitters is paramount in achieving a working device. All of the above, points strongly to the fact that it was indeed not by any means an obvious step to combine the teachings of the two patent documents relied on by the examiner.

Further, applicants direct the examiner's attention to some parallel results carried out to compare their one layer system which uses the BF₂ complex with the one layer system which is employed in Mori et al U.S. '489, which uses a coumarin 6 layer dye. From this parallel testing, the brightness measured for the device comprising a layer doped with coumarin 6 was 187cd/m². The brightness measured for the device which used 1,3,5,7,8-pentamethyl-2,6-di-n-butylpyrromethene-difluoroborate, however, was 281 cd/m². Therefore the device made according to the present invention achieved a brightness which is 50% greater than with that made according to the prior art. Further as the drive current and voltage were the same, the device made according to the present invention achieved a power efficiency 50% higher than the prior art device. (A copy of the experiment is attached for the examiner's convenience.) In the light of the above discussions on efficiencies, these results give strong support to the unobvious and unexpected properties of the devices of the present invention.

In conclusion, the above discussion shows clearly that applicants' one layer device is both novel and inventive over the two layer system disclosed in JP '081 and that the teachings of the one layer system by Mori et al U.S. '489 would not direct the person skilled in the art to produce a one layer system with compounds according to the present invention. Further, the objections raised by the examine to claims 2 to 11, as discussed in paper 5 will now be acceptable by way of their association with claim 1.


For the above reasons it is respectfully submitted that the claims of this application define inventive subject matter. Reconsideration, entry of this Amendment and allowance are solicited.

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